GOOD PRACTICE GUIDE 345

Domestic heating by electricity

- information for developers, architects, specifiers, landlords and others responsible for selecting heating and hot water systems
- costs, environmental factors, design considerations, appliances and controls

BEST PRACTICE PROGRAMME

HOUSING ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

GOOD PRACTICE GUIDE 345

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Cover photographs supplied courtesy of: Renewable Energy Systems (wind farm at Dun Law, top);
Corbis (Drax power station, bottom left), Glen Dimplex (panel heater, top right) and
Applied energy (radiant fire and storage heater, middle and bottom right)

INTRODUCTION/FUEL SELECTION

INTRODUCTION

This Guide deals with electric direct acting and storage heating and hot water, together known as electrical resistance heating. Electric heating using additional energy sources (eg heat pumps, heat recovery from ventilation, solar collectors, micro-CHP) requires different technology and special consideration, and is explained in other publications – see Ref [1] for an introduction and also Refs [2], [3] and [4].

In general, heating by electricity has substantially higher fuel costs and greater carbon emissions than alternative fuels, although installation and maintenance costs are lower. Consequently dwellings with electric heating receive relatively poor energy ratings. Recent changes to building regulations differentiate between electric heating and other types, and have made it more difficult to comply when electric heating is installed because of the greater carbon burden.

The best practice recommendation is that electric heating should be considered only in limited circumstances – mainly small and well-insulated properties.

FUEL SELECTION

Unlike most domestic appliances, heating and hot water systems are produced for a variety of different fuels (gas, oil, LPG, electricity, coal, wood), and the purchaser has a choice. But selection must be made at an early stage, as it affects the provision and distribution of building services and (if needed) storage containers.

Heating appliances for different fuels are manufactured and installed by different industries in competition with one another. It is important to be aware of the range of alternatives and to understand the principal characteristics of the main fuels – especially the economic and environmental consequences of the final choice. These are discussed in Ref [1]. Central heating systems with gas or oil fired boilers are dealt with separately in Ref [5].

Figures for heating efficiency are often quoted, but any meaningful comparison between fuels must take account of the whole energy supply chain, progressing through primary energy, delivered energy, and useful energy. Simply stated, primary energy is that required at source before it can be distributed and delivered; delivered energy is that supplied to the home and the basis for payment; and useful energy warms the home or heats the water.

Conversion from primary to delivered, and delivered to useful, energy involves wastage and losses, which reduce the overall efficiency of the supply chain. For the national electricity supply, conversion efficiency of primary to delivered energy is around 35% to 45%, depending on the mix of generating equipment in use. But conversion efficiency of delivered to useful energy is very high for electric heating, and can normally be taken as 100% irrespective of the type or make of appliance used. In contrast, for gas and oil there is less difference between primary and delivered energy, but the conversion efficiency of delivered to useful energy is about 70% for gas boilers (housing stock average) or 90% (best modern products). The efficiency of boilers is discussed in Ref [5] and can be seen on the website at Ref [6].

Photograph courtesy of Applied Energy

ENVIRONMENTAL IMPACT/RELATIVE COSTS

ENVIRONMENTAL IMPACT

The environmental impact, and cleanliness in the wider sense, of different fuels should be considered in relation to the primary energy needed to produce each unit of useful energy required. For heating systems, carbon dioxide emissions are the main environmental consideration, and the amount emitted for any given heating requirement varies according to the fuel used and the efficiency of conversion. This is shown in Table 1, where the heat requirement for a house on a cold winter day is the same irrespective of fuel (see the column 'useful energy'), but the delivered energy, primary energy, running costs, and carbon emissions vary widely according to fuel and heating system employed.

RELATIVE COSTS

The economic factors affecting choice of heating system are purchase and installation costs, maintenance costs, and running costs. In a whole-life cost analysis these would be combined using a discounted cash flow technique to produce a net present value (NPV). The discount rate varies with economic conditions, and at present (February 2003) would be around 3 to 4%. The NPV provides a realistic basis for comparison of different types of heating systems and fuels.

Running costs include fuel and standing charges. For small properties with very low heating and hot water requirements, any additional standing charges may be large enough to cancel the benefit of the lower unit cost of the heating fuel (whether off-peak electricity or gas). Under some tariffs standing charges have been replaced by higher unit charges for the first units used in each charging period. Purchase, installation and maintenance costs for an electric heating system with storage radiators and direct acting heaters will be lower than for a heating system with a boiler and radiators, and there is no statutory requirement for an annual safety check in rented properties. However, fuel costs will be significantly higher, and with most supply tariffs they depend critically on the proportion of off-peak electricity used. Some means of heat storage is needed to make effective use of the off-peak tariff. A calculation of the running costs for space and water heating is used to develop an energy rating for SAP (see panel).

For a reasonable lifetime of the equipment in average homes – say 15 to 20 years – it is likely that running costs will be dominant. Heating and hot water are the largest components of energy consumption. In the UK housing stock as a whole, it is estimated that about 58% of energy is consumed for space heating and 24% for hot water. For new housing the difference between these two components is much smaller, though even in extremely well insulated properties there will remain a substantial energy requirement for hot water. Table 2 shows comparative annual fuel costs (ignoring other annual costs) for different types of system in typical properties. Table 3 shows the corresponding carbon emissions.

Table 1: Heating and hot water energy requirement on a cold winter day
(16 hours heating; external temperature -1°C; house of slightly above average size with typical construction and insulation. Primary energy factors from Ref [7]; fuel costs and carbon emissions from Ref [8].)

	Useful energy kWh	Delivered energy kWh	Primary energy kWh	Cost	CO_2 emitted kg
Electricity - standard tariff	100	100	280	£7.09	41
Electricity - off-peak	100	100	280	£2.85	41
Gas boiler - new condensing	100	111	128	£1.50	22
Gas boiler - new non-condensing	100	128	147	£1.73	25
Gas boiler - stock average	100	143	164	£1.92	28
Oil boiler - new condensing	100	108	128	£1.75	29
Oil boiler - new non-condensing	100	118	140	£1.92	32
LPG boiler - new non-condensing	100	125	137	£3.70	31
Coal boiler	100	167	178	£2.77	49

SAP (Standard Assessment Procedure)

SAP is the UK Government's procedure for calculating home energy ratings (see Ref [8]). Insulation and other properties of the building determine the heat requirement. The type of heating system and fuel used determine the energy, cost, and carbon dioxide emitted. The SAP index is a number from 1 to 120, based on the calculated cost of space and water heating, and higher numbers represent better energy performance. All newly created homes in the UK must have a SAP rating to comply with building regulation procedures.

ANNUAL FUEL COSTS AND CO_2 EMISSIONS

	Existing Housing					New Housing				
	Flat	Bungalow	Terraced	Semi-detached	Detached	Flat	Bungalow *	Terraced *	Semi-detached*	Detached *
Electricity – standard tariff	£656	£859	£895	£1,013	£1,436	£214	£269	£269	£335	£398
Electricity – off-peak	£264	£346	£360	£408	£578	£86	£108	£108	£135	£160
Gas boiler – new condensing	£138	£181	£189	£214	£303	£45	£57	£57	£71	£84
Gas boiler – new non-condensing	£160	£209	£218	£247	£350	£52	£65	£65	£82	£97
Gas boiler – stock average	£178	£233	£243	£275	£390	£58	£73	£73	£91	£108
Oil boiler – new condensing	£162	£212	£221	£251	£355	£53	£66	£66	£83	£99
Oil boiler – new non-condensing	£178	£232	£242	£274	£389	£58	£73	£73	£91	£108
LPG boiler – new non-condensing	£342	£448	£467	£529	£749	£111	£140	£140	£175	£208
Coal boiler	£230	£301	£313	£355	£503	£75	£94	£94	£117	£140

Table 2: Annual fuel costs for heating and hot water in different property types

	Existing Housing					New Housing				
	Flat	Bungalow	Terraced	Semi-detached	Detached	Flat	Bungalow *	Terraced *	Semi-detached*	Detached *
Electricity – standard tariff	3.83	5.01	5.22	5.92	8.38	1.78	2.24	2.24	2.79	3.32
Electricity – off-peak	3.83	5.01	5.22	5.92	8.38	1.78	2.24	2.24	2.79	3.32
Gas boiler – new condensing	2.00	2.62	2.73	3.09	4.37	0.93	1.17	1.17	1.46	1.73
Gas boiler – new non-condensing	2.31	3.02	3.14	3.56	5.05	1.07	1.35	1.35	1.68	2.00
Gas boiler – stock average	2.57	3.36	3.50	3.97	5.63	1.19	1.51	1.51	1.87	2.23
Oil boiler - new condensing	2.69	3.52	3.66	4.15	5.88	1.25	1.58	1.58	1.96	2.33
Oil boiler - new non-condensing	2.94	3.85	4.01	4.54	6.44	1.37	1.72	1.72	2.15	2.55
LPG boiler - new non-condensing	2.88	3.76	3.92	4.44	6.29	1.34	1.68	1.68	2.10	2.49
Coal boiler	4.50	5.89	6.13	6.95	9.85	2.09	2.63	2.63	3.28	3.90

Table 3: CO_2 emissions (tonne/year) for heating and hot water in different property types

Notes on Tables 2 and 3:

- *Fuel prices: these are taken from Table 12 of SAP 2001 (Ref [8]).*
- *Carbon intensities: these are taken from Table 15 of SAP 2001 (Ref [8]).*
- *Property types: for existing housing, they are typical of the housing stock as analysed in Ref [7]. For new housing, they are properties of the same floor area but with improved insulation standards which would comply with Building Regulations 2000 (Ref [9]) if gas heating were installed. For comparison, the same new housing properties are used throughout the Tables, but those marked * may fail to meet Building Regulations if electric heating is installed as further improvements to insulation are then required. The flat is a top-floor flat, which has energy consumption between a ground and mid-floor flat. Hot water consumption is related to the number of occupants.*

GREEN ELECTRICITY/DESIGN CONSIDERATIONS

CARBON INDEX (CI)

The Carbon Index (CI) is calculated as part of the SAP procedure. Carbon dioxide is emitted as a result of burning fossil fuel, or generating electricity, to meet the demand for space and water heating. The CI is based on emission adjusted for floor area, so that it is almost independent of dwelling size. The CI is expressed on a scale of 0.1 to 10.0, where higher values are better (representing lower carbon dioxide emissions).

GREEN ELECTRICITY

'Green' electricity, meaning electricity generated from renewable sources, is a small but growing proportion of the national supply and has near-zero carbon intensity – see Ref [10]. Consumers may elect to purchase green electricity under special tariffs, but supply agreements do not alter the Carbon Index for buildings calculated under SAP (Ref [8]), nor do they change restrictions under the building regulations.

The availability of green electricity should not be used to justify selection of electric heating, although when electric heating is chosen for other reasons then the arguments for purchasing green electricity still apply.

Photograph courtesy of National Wind Power Ltd

DESIGN CONSIDERATIONS

In dwellings, the design of space heating and hot water systems is considered together, as many solutions use shared equipment and appliances. In a new house with SAP rating 85, the energy consumed for heating and hot water might be roughly equal, and as insulation is improved further and the SAP rating increased, hot water is likely to become the dominant load. But there is a very wide variation in the demand for heating and hot water, even in apparently identical households.

For satisfactory performance and economic operation, electric heating systems depend upon careful and responsible design. For heating systems with storage heaters, detailed design guidance is given in Ref [11], and similar methods have been developed separately by electricity suppliers following the principles established by CIBSE (Ref [12]). A draft European standard (Ref [13]) for design of electrical heating systems is currently (February 2003) in preparation, though it is not exclusively for housing.

In the UK, specifiers of heating for new housing will be concerned initially with the relevant parts of the building regulations that deal with conservation of fuel and power (see page 7).

COMPLIANCE WITH BUILDING REGULATIONS

U-VALUES

U-values are a scientific measure of thermal transmittance, and are used to express how much heat passes through a wall or other external element of a building. The heat flow per unit of surface area per degree of temperature difference of the air on either side is measured in units of watts per square metre per degree Kelvin. Lower figures are better, as they represent better insulation qualities with a smaller rate of heat loss.

COMPLIANCE WITH BUILDING REGULATIONS

The building regulations (Refs [9], [14], [15]) contain provisions for conservation of fuel and power. There are different building regulations in England and Wales (Part L1 of the Building Regulations), in Scotland (Part J of the Technical Standards for compliance with the Building Standards (Scotland) Regulations), and in Northern Ireland (Technical Booklet F of the Building Regulations (Northern Ireland) 2000). In each case they differentiate between electric and other heating systems, with more demanding levels of compliance for electric heating because of the higher rate of carbon dioxide emission. To meet the regulations when electric heating is used it is necessary to improve the insulation of the building fabric, which affects the building construction process and costs.

England and Wales

In England and Wales there are three alternative methods of demonstrating compliance with Part L1 of the Regulations (Ref [9]). The first method, known as the Elemental Method, is not allowed for electric resistance heating systems. The second method is known as the Target U-value Method, where 'U-value' refers to the rate at which heat is lost by conduction through the fabric of the building (see panel above). Under the Target U-value Method, an average is calculated for the various elements of the building envelope, and it must not exceed a target value that depends on the ratios of total floor, ground floor, and roof areas to the total area of all exposed elements of the dwelling. The target value is reduced (ie made more demanding) by dividing by a factor of 1.15 when electric heating is used. The effect of the reduction is analysed in Ref [16], where it is explained that it is hard to meet the lower target except in flats with a low ratio of window to floor area. The third method of demonstrating compliance is the Carbon Index Method (see page 6), by which a result of 8.0 or higher must be obtained when the overall energy performance of the building is assessed under SAP (Ref [8]) – however, it will be harder to satisfy the Regulations by this method as the carbon intensity of the heating fuel is taken into account in the calculation. Part L1 also requires storage heaters to have automatic charge control (explained later).

Scotland

In Scotland the three methods of demonstrating compliance with Part J of the Technical Standards (Ref [14]) are similar in principle to those in England and Wales, though there are differences in the calculations. It is permissible to use the Elemental Method with electric heating, but the maximum allowable U-values of the elements are lower (harder to achieve) than for gas and oil central heating systems where the boiler efficiency is known. Under the Target U-value Method, the target is reduced (ie made more demanding) by dividing by a factor of 1.15 when electric heating is used. For the CI Method, a result of at least 8.0 must be reached.

Northern Ireland

In Northern Ireland, for new dwellings there are two methods of demonstrating compliance with Technical Booklet F of the Building Regulations (Northern Ireland) 2000 (Ref [15]). For both methods a SAP rating must first be calculated, and different requirements then apply according to whether or not the result exceeds 60. Under the Elemental Method, there are maximum U-values for elements of the building fabric, and, for a SAP rating of 60 or below, lower maxima apply but no distinction is made between electric and other types of heating. Under the Target U-value Method, the target is calculated by reference to the total floor area and total area of exposed elements, and raised (ie relaxed) where the SAP rating exceeds 60. The target can be relaxed further for certain types of heating system, but not for electric resistance heating.

WHAT IS BEST PRACTICE?/ELECTRICITY TARIFFS

WHAT IS BEST PRACTICE?

Best practice requires good insulation and glazing and consideration of other options before finally deciding on electric heating. The standards for new and existing dwellings are set out in General Information Leaflet 72: Energy Efficiency Standards for new and existing dwellings (Ref [17]) and Good Practice Guide 155: Energy efficient refurbishment of existing housing (Ref [18]). Electric heating can be considered best practice when all the following conditions have been met:

- the property is well insulated, well glazed, and draught-proofed. New housing should meet conditions described under 'Best Practice Standard – basic requirements' in Ref [17] and have a CI of at least 6.8. Existing housing should meet the refurbishment standard described under 'Existing Housing' in Ref [17], which is based on established recommendations in Ref [18].
- the total heating and hot water requirement is small, such that the estimated net present value of the heating and hot water service (from whole-life cost analysis) is lower for electricity than for other fuels and systems over the same period.
- a suitable design method (such as in Ref [11]) has been used to ensure that a reasonable proportion of electricity for heating and hot water is provided at off-peak rates, using appliances or installations with adequate heat storage capacity.
- storage heating systems have automatic charge control.
- storage heaters in intermittently occupied rooms are fan-assisted, to improve responsiveness.
- the hot water cylinder is large enough to supply most of the hot water demand between off-peak periods, is well insulated to a high specification such as 'MAXISTORE', and has dual immersion heater elements.
- good controls, preferably managed from one central unit, are provided for time and temperature programming, with separate zones for living and sleeping areas.

Where the conditions cannot easily be met then other solutions are indicated; for example wet central heating with condensing boilers. In flats and high-density residential areas, community heating should be considered, sharing one or more large boilers or a CHP (combined heat and power) unit – see Refs [19] and [20]. The Government Community Energy Programme (see Ref [21]) offers grant funding for such schemes.

ELECTRICITY TARIFFS

There is a wide range of tariff types and price offerings from competing electricity suppliers, and it is worthwhile searching for the most favourable. This can be done on the website at Ref [22]. The most common off-peak tariffs offer 7 hours between midnight and early morning, though some also offer a short top-up period at other times. When an off-peak tariff is chosen, the price of electricity outside the off-peak period is described as the on-peak price, and is not usually the same as the single price under the standard tariff. Although standard and on-peak electricity prices have fallen over the last few years, off-peak prices have risen slightly. Prices vary in different parts of the UK – see Table 4 for prices used in SAP 2001, which are calculated from 3-year averages. Electricity suppliers have various special tariffs designed for electrically heated homes, some of which provide 24-hour remote control of separate circuits for space and water heating – see under 'Controls: Whole systems'.

		UK average
Standard tariff	p/kWh	7.09
On-peak	p/kWh	7.49
Off-peak (7-hour) – additional off-peak standing charge	p/kWh £/yr	2.85 16
Electricity – 24-hr heating tariff – additional standing charge	p/kWh £/yr	3.23 48

Prices in Northern Ireland are 10% to 30% higher than the UK average

Table 4: Electricity prices including VAT (SAP 2001)

HEATING UNITS

STORAGE HEATERS

Electric storage heaters are designed to take advantage of the off-peak electricity tariffs under which electricity is supplied at a lower price for a few hours per day. The principal performance characteristics are storage capacity and rate of heat emission, and effective controls are particularly important. As storage heating is less responsive to changes in demand, features that allow the emission rate to be altered readily are desirable. The amount of storage needed to meet daily heating requirements should be considered carefully at the design stage, and may be calculated following the principles in Ref [11].

Storage heaters are larger, heavier, and more expensive than direct acting (instantaneous) heaters, and require more complex controls for satisfactory performance, but offer a substantial reduction in fuel costs. Each heater is wired independently to a separate consumer unit connected to the off-peak supply, and, as for all electrical installation work, the IEE Wiring Regulations (Ref [23]) must be observed.

Storage heaters are charged with heat during the off-peak periods, and release it slowly over a far longer period. They perform better in well-insulated draught-proofed homes, where heat is lost from the building more slowly and is not strongly affected by sudden changes in the weather (eg, changes in wind speed). Storage heaters are manufactured in a range of sizes with storage capacity quoted in kWh, and a typical heater is capable of being charged at a rate of 3.4kW and able to accept a maximum charge of 24 kWh in a 7 hour charging period. It is important to set overnight charging correctly: failure to do so leads either to insufficient storage for the next day's requirements, in which case more heat will be wanted from direct acting heaters at the more expensive on-peak rate, or an excessive amount that will be wasted if mild weather reduces the need for heating. Automatic charging systems are preferable, and there are several types – see 'Controls' (page 11).

In the simplest storage heaters the rate of heat release cannot be controlled, but more advanced models have a mechanical damper that is thermostatically controlled and can be altered by the householder. Greatly improved control can be provided by a fan that is connected to a separate electrical circuit and can be switched on at any time (manually or by thermostat) to increase the rate of heat output. These features help to make storage heating more responsive to need, and are especially valuable in rooms not occupied continuously throughout the day.

In general, heating by storage heaters consumes more energy than direct acting heaters, though the margin will be small in houses that are well insulated or occupied continuously throughout the day. Design of a satisfactory heating system using storage heaters requires some care to manage the different time periods for charging and heat release, and a design method is explained in detail in Ref [11]. It is not normally practicable or cost effective to aim for heating by storage appliances alone, and provision should be made for some supplementary direct acting heating. A reasonable proportion of the annual heating to be provided at off-peak rates should be decided by design method: traditionally this has been 90%, as discussed in Ref [11], but lower proportions are justified in very well insulated properties.

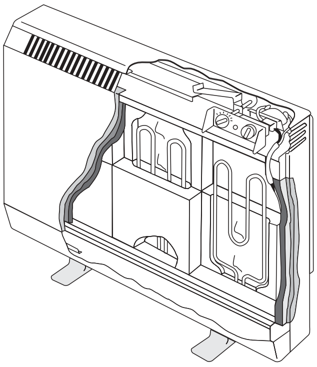
DIRECT ACTING (INSTANTANEOUS) HEATERS

Direct acting instantaneous heaters are simpler than storage heaters, and cheaper to purchase and install. They do not retain heat for later release, and are used on demand by the occupants of the household. Direct acting electric heating of all types will have similar costs and environmental impact, though different operation and controls may change the distribution of heat and affect the air temperature at which occupants feel comfortable. The principal performance characteristic is rated output in kW, against which claims for economy or power should be judged.

Heating by direct acting electric heaters is more expensive, as they are unable to take full advantage of the off-peak tariffs, and will be supplied mostly at the standard or on-peak rates. They are often connected to the general purpose household power circuits that have socket outlets or connection points rated at 13 amps (the ring main), in which case the total circuit rating of 30 amps (about 6.9kW) must be observed. To comply with the 13-amp limit on individual appliances connected to a ring main, most direct acting heaters are designed with a maximum rating no greater than 3kW.

Photograph courtesy of Glen Dimplex

Electric storage heater



Construction of a typical electric storage heater

HEATING UNITS

Photographs courtesy of Glen Dimplex

Convector heater (top)
Panel heater (middle)
Radiant heater (above)

There is a wide variety of appliances for direct acting electric heating. They can be categorised as convectors, panel heaters, fan heaters, and radiant heaters, and all are equally efficient in converting delivered to useful energy. Convectors are designed to give out most of their heat as warm air that rises naturally (or with fan assistance) and circulates slowly in convection currents. Panel heaters are slimmer, and also give out a large proportion of heat by convection but with some radiation from the hot front surface as well. Convector and panel heaters are either portable or made for wall mounting, and are intended to meet heating requirements over longer periods: to offer some degree of automatic control they are often fitted with thermostats. Fan heaters are often portable and circulate air within the room very rapidly, responding well to short term demands; wall-mounted models are suitable for fixed installation at high level in bathrooms. Radiant heaters are better suited to short term comfort heating in small areas: they are either portable or intended as installed features, often designed for attractive appearance.

WARM AIR UNITS

A single storage unit, charged from the off-peak electrical supply, can be installed in a central position and warm air supplied from it to nearby rooms. This works best in small compact properties where heat can be discharged through grilles at the sides of the unit rather than via long ducts. A fan within the unit controls air movement and rate of heat output, and the warm air supply to different rooms is balanced by making adjustments to the outlet grilles. The central unit will need sufficient heat storage capacity for all the rooms to be heated, so will be larger than an individual room storage heater and require a higher rated electrical circuit.

BOILERS

Electric boilers are designed for connection to a hot water distribution system with radiators. Electric boiler systems without heat storage (either within the boiler or in a separate water store) are expensive to run, and some form of heat storage is essential to reduce running costs and high power demand at times when the domestic electricity supply is likely to be heavily loaded with other requirements. Allowance for space for the heat store should be considered at an early stage.

FLOOR HEATING

Embedded electric elements use the mass of the floor material to store heat accumulated overnight and release it slowly through the day. Floor heating responds slowly to change in demand, and requires careful control to provide satisfactory and economic heating performance. Elements laid on top of the floor (rather than embedded) are unable to make such effective use of the floor mass for storage, and will require a larger proportion of heating at on-peak rates.

CEILING HEATING

Ceiling heating is unsuitable as the principal heating system in domestic conditions as it does not provide adequate comfort, and should only be considered for supplementary heating.

WATER HEATERS

Domestic hot water in the UK is traditionally heated and stored in upright copper cylinders, although electric 'white cased' storage vessels, more common in continental Europe, are also available. Cylinders are available both for vented systems, where the pressure is limited by a supply cistern usually installed in the loft, and for unvented systems connected directly to the incoming water supply. The latter have the advantage of supplying hot water at mains pressure, which is better for showers. In each case electrical immersion heaters are installed, and to minimise temperature stratification of the hot water horizontally mounted heater elements are preferable to vertical ones.

For economy it is desirable to make use of the off-peak electricity tariff, and it is then important to ensure the storage vessel is large enough to supply the hot water demand between off-peak periods, and is especially well insulated to maintain temperature throughout the day. Cylinders are made to a higher specification, such as 'MAXISTORE', to meet this requirement, and design advice is given in Ref [24].

CONTROLS

A volume of 144 litres is recommended for small households (one or two persons) and 210 litres or more for larger households. Twin immersion heaters, or a dual element single immersion heater, can be installed and connected such that a small quantity of hot water at the top of the vessel is always available as it is heated from the permanent electrical supply (mainly on-peak), but a larger volume (eg for baths) is heated during the off-peak periods to save costs.

CONTROLS

Controls for electric heating help to match heating performance to individual occupancy patterns and preferences, and are strongly recommended to avoid waste and unnecessary expense. The following types should be considered:

Individual storage heaters: charging

- **Manual control:** provided within each appliance to be adjusted by the householder every night in anticipation of the next day's heating requirements.
- **Automatic control:** detects the rate of temperature fall during the night and brings on the charge accordingly. This has been found to be the most accurate form of control.
- **Weather sensing control:** reacts to measured indicators of the next day's requirements, such as the present indoor or outdoor temperature. May be either a part of each heater, or installed independently for a group of heaters.
- **Weather prediction control**: offered by the electricity supplier in conjunction with a special tariff, allowing the supplier to alter the charging period for all the storage heaters to suit the weather forecast.

Individual storage heaters: heat emission

- **Mechanical damper**: set by the householder, in conjunction with an integral thermostat.
- **Fan with manual switch and/or thermostat and timer control**: greatly improves the range of controllable heat output (although the fan is a construction feature rather than a control).
- **Fan with central control**: the fan is controlled separately from a central thermostat and timer or programmer.

Direct acting heaters

- **Thermostat**: prevents over-heating of rooms when heaters are left on for long periods. Can be installed separately, in a better position for temperature measurement away from the heating appliances.
- **Time switch**: avoids wastage by allowing householder to match heating periods to pattern of occupation, and allows pre-heating without manual intervention. Can be installed separately if not provided within the appliance.

Water heaters

- **Integral thermostat**: all immersion heaters must have one to limit water temperature.
- **Time switch**: minimises heat losses by allowing occupants to choose heating times to meet personal hot water usage requirements; also used to exploit off-peak rates where an off-peak supply is available but the heater is not permanently wired to it.
- **Switching of dual elements**: enables second heater element to be switched on or off at any time, where first element is permanently wired to an off-peak supply.

Whole system

- **Central programmer**: gives independent time and temperature control in two or more space heating zones in accordance with a programme set by the user. It may also control the hot water cylinder. There are communication and control paths (wired or wireless) to a number of room sensors and separate heaters. It may control panel and convector heaters only, or, in the case of CELECT-type systems, it may also be capable of optimising the charging of individual storage heaters.
- **24-hour (or other) special tariff**: 24-hour remote control by the electricity supplier of separate circuits for one or more of: (i) storage heating with weather-dependent control, (ii) stored hot water, and (iii) unrestricted 'top-up' of both space heating (using direct acting heaters) and water heating.
- **Load-management special tariff**: the electricity supplier switches heating loads on and off, within agreed time limits, and offers lower prices in return.

Controls for electric heating are described further in Ref [25].

Photograph courtesy of Applied Energy

Dual element immersion heater

Photograph courtesy of Glen Dimplex

Storage heater controls

Photograph courtesy of Applied Energy

Zone controller

Photograph courtesy of Applied Energy

Hot water control

REFERENCES

REFERENCES

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